

CLAIMS

What is claimed is:

1. A method of induction heat treatment, comprising the steps of:

selecting an article for heat treatment having a longitudinal axis of rotation and an outer surface having an upper section, a lateral section and a lower section, and comprising a plurality of points having a plurality of normal spacings from the axis of rotation;

selecting an induction coil comprising a semi-cylindrical upper coil portion, a semi-cylindrical lateral coil portion, a semi-cylindrical lower coil portion and a longitudinal axis, which is adapted to receive the article for heat treatment and apply a non-planar magnetic field to the outer surface of the article;

placing the article within the induction coil;

rotating the article within the induction coil at a selected speed;

energizing the induction coil to apply the non-planar magnetic field and produce induction currents within the outer surface of the article for a time sufficient to induce heating of the outer surface to a heat treatment temperature (T_H) to at least a selected case depth; and

cooling the outer surface of the article to a temperature (T_C) to the selected case depth.

2. The method of claim 1, wherein the article comprises a pearlitic/ferritic steel.

3. The method of claim 2, wherein T_H is greater than the austenite transition temperature.

4. The method of claim 3, wherein said step of cooling comprises quenching the article.
5. The method of claim 4, wherein said step of cooling comprises quenching until T_C is lower than the martensite transformation temperature.
6. The method of claim 1, wherein the article comprises an inner ball race of a Rzeppa-type constant velocity joint having a barrel-shaped outer surface with a plurality of longitudinally extending arch-shaped grooves formed therein.
7. The method of claim 6, wherein the inner ball race comprises a pearlitic/ferritic steel.
8. The method of claim 7, wherein the steel comprises AISI 1050 steel.
9. The method of claim 7, wherein T_H is greater than the austenite transition temperature.
10. The method of claim 9, wherein the T_H is in the range of 1700 - 2000°F.
11. The method of claim 9, wherein said step of cooling comprises quenching the article.

12. The method of claim 11, wherein T_C is less than the martensite start temperature and greater than the martensite finish temperature .

13. The method of claim 12, further comprising stopping the quenching when the outer surface of the inner race is less than or equal to T_C to the selected case depth, and then permitting the inner race to cool under ambient conditions.

14. The method of claim 1, wherein during the step of energizing, the upper coil portion produces an upper magnetic field that is adapted to act on the upper section of the outer surface, the lateral coil portion produces a lateral magnetic field that is adapted to act on the lateral section of the outer surface, and the lower coil portion produces a lower magnetic field that is adapted to act on the lower section of the outer surface.

15. The method of claim 14, wherein the step of energizing comprises the application of an electric current to the induction coil having a frequency in the range of about 7.5 - 12 kHz.

16. A method of induction heat treatment of an outer surface of an inner ball race of a Rzeppa-type constant velocity joint, said outer surface also having a plurality of ball races formed therein, comprising the steps of:

selecting an induction coil having a longitudinal axis, a semi-cylindrical upper coil portion, a semi-cylindrical lateral coil portion and a semi-cylindrical lower coil portion, that is adapted to receive the inner race and apply a non-planar magnetic field to the outer surface thereof;

placing the article within the induction coil;

rotating the inner race within the induction coil at a selected speed;

energizing the induction coil to apply the non-planar magnetic field and produce induction currents within the outer surface of the inner race for a time sufficient to induce heating of the outer surface to a heat treatment temperature (T_H) to at least a selected case depth; and

cooling the outer surface of the article to a temperature (T_C) to the selected case depth.

17. The method of claim 16, wherein the inner race comprises a pearlitic/ferritic steel.

18. The method of claim 17, wherein the steel comprises AISI 1050 steel.

19. The method of claim 17, wherein T_H is greater than the austenite transition temperature.

20. The method of claim 19, wherein T_H is in the range of 1700 - 2000°F.

21. The method of claim 19, wherein said step of cooling comprises quenching the article.

22. The method of claim 21, wherein said step of cooling comprises quenching until T_C is lower than the martensite start temperature.

23. The method of claim 22, wherein T_C is greater than the martensite finish temperature.

24. The method of claim 23, further comprising stopping said step of cooling by quenching when the outer surface of the inner race is less than or equal to T_C to the selected case depth, and permitting the inner race to cool under ambient conditions.

25. An article, comprising:
a steel inner race of a Rzeppa-type constant velocity joint having a barrel-shaped outer surface and a core, the barrel-shaped outer surface having a plurality of angularly spaced apart, longitudinally extending, arch-shaped ball races, the outer surface including the plurality of arch-shaped ball races having a hardened case, wherein the hardened case is formed by an induction heat treatment.

26. The article of claim 25, wherein the induction heat treatment comprises the steps of selecting an induction coil having a longitudinal axis, a semi-cylindrical upper coil portion, a semi-cylindrical lateral coil portion and a semi-cylindrical lower coil portion, that is adapted to receive the inner race and apply a non-planar magnetic field to the outer surface thereof; placing the article within the induction coil; rotating the inner race within the induction coil at a selected speed; energizing the induction coil to apply the non-planar magnetic field and produce induction currents within the outer surface of the inner race for a time sufficient to induce heating of the outer surface to a heat treatment temperature (T_H) to at least a selected case depth; and cooling the outer surface of the article to a temperature (T_C) to the selected case depth.

27. The article of claim 26, wherein the induction hardened case comprises a martensitic microstructure and the core comprises a microstructure that is a mixture of pearlite and ferrite.

28. The article of claim 27, wherein the induction hardened case has a hardness of about R_C 58-63, and the core has a hardness of about R_C 15-30.

29. The article of claim 27, wherein the martensitic microstructure is a tempered martensitic microstructure.

30. The article of claim 29, wherein the tempered martensitic microstructure is formed by the induction heat treatment.

31. The article of claim 30, wherein the tempered martensitic microstructure has a hardness of about R_C 58-61.

32. The article of claim 31, wherein the depth of the case is about 1 – 1.8 mm in the arch-shaped ball races and about 2.5 – 5 mm on the bearing portions.

33. An induction coil, comprising:

a hollow metal channel comprising a first termination portion, a generally cylindrical inductor portion and a second termination portion, the inductor portion comprising a first semi-cylindrical upper section which is connected to a first semi-cylindrical lateral section which extends downwardly and is connected to a semi-cylindrical lower section which is connected to a second semi-cylindrical lateral section which extends upwardly and is connected to a second semi-cylindrical upper section, wherein the first termination section is connected to an end of the first semi-cylindrical upper section that is opposite the first semi-cylindrical lateral section, and the second termination portion is connected to an end of the second semi-cylindrical upper section that is opposite the second semi-cylindrical lateral section, wherein the first termination portion, cylindrical portion and second termination portion are operably connected to one another and adapted to conduct an induction current.

34. The induction coil of claim 33, wherein the hollow channel is rectangular having an outer width of about 12.7 mm and an outer height of about 9.5 mm and a wall thickness of about 1.1 mm.

35. The induction coil of claim 33, wherein the metal is pure copper.